

Crinoid morphology to regard their resemblances as due to homogeny rather than to homoplasy.

Imperforate Articulation.

Reference to "British Fossil Crinoids," II. p. 314, will show that there is some difficulty in distinguishing between those forms of joint that are there called "Loose suture" and "Muscular articulation." There are among Inadunate Crinoids many instances of arm-joints in which there is a well-defined fulcral ridge, combined with muscular and ligamental depressions, but in which the axial canal does not happen to be separated from the ventral groove by stereom and so does not perforate the fulcral ridge. It might be advisable to distinguish these joints as "Imperforate articulation," and to call the muscular articulation in which "the articular ridge, whether vertical or transverse, is always perforate," "Perforate articulation."

It is unfortunately necessary to explain that the word "joint" is used here and throughout my papers in its ordinary English and anatomical sense, and not in that restricted and different sense which is usually ascribed to it by crinoidologists and cooks.

VIII.—*On the Oviposition and Embryonic Development of the Crocodile.* By Dr. A. VOELTZKOW, of Majunga, Madagascar*.

THE Madagascar Crocodile, *Crocodylus niloticus*, Laur. (*madagascariensis*, Grandid.), is not only one of the commonest reptiles, but perhaps the commonest Vertebrate of the island. It is found in large numbers wherever there is water, in every pool and stream. The natives distinguish two species, one (*Cr. niloticus*) with a longer, and another with a shorter head and greater length of body; the latter is said to occur only in the large rivers in the primeval forest, and the natives are extraordinarily afraid of it, as it is stated to be very savage; it is probably identical with *Cr. robustus*, Vaill., Grandid. I

* Translated from the 'Mathematische und Naturwissenschaftliche Mittheilungen aus den Sitzungsberichten der Königlich Preussischen Akademie der Wissenschaften zu Berlin,' Heft ii., 1891, pp. [115] 51-56 [120].

have not yet succeeded in securing a specimen of this second species; my remarks therefore refer exclusively to *Cr. niloticus*, Laur. (*madagascariensis*, Grandid.).

This animal is met with in all sizes, especially numerous on the sandbanks of the Betsiboka River, where, in the space of an hour, in rowing down the river, a hundred and more may be readily observed. The largest which I have yet measured was 13 feet in length, though individuals of considerably larger size occur.

Oviposition commences in the latter days of August, and continues until towards the end of September*, after which I found that the eggs all contained embryos. Altogether rather more than one thousand eggs were submitted to examination, derived from about thirty-five batches. In a few cases the number of eggs in the batch could not be exactly determined. The number of eggs in a batch varies between twenty and thirty.

The nest consists of a pit excavated in the earth to the depth of about a foot and a half to two feet, with partially steep walls. At the bottom of the pit the walls are undermined, and here the eggs are placed. The floor of the pit is raised slightly in the middle, so that the eggs, as they are laid by the female, roll by themselves into the hollowed-out places. Very rarely one or two eggs are found lying in the middle of the pit, which may well be taken as proving that the mother does not herself push the eggs into the hollows with her feet, for in that case no eggs would ever be found in the centre of the pit. After the eggs are laid the pit is filled in, and no sign of it can be detected from above. The old crocodile sleeps upon the nest, and this enables the natives to find the eggs, since they follow the tracks of the animal from the water.

The shape of the eggs is extremely variable, and not even those of the same batch resemble each other completely; many are elliptical, others cylindrical with rounded ends; two eggs were pointed at one end. In size they vary from $5\frac{1}{2}$ to 9 centim. in length and from 4 to 5 centim. in breadth. The shell is white, thick, and hard, sometimes coarsely granular, sometimes smooth.

Almost all the nests were dug in the dry white sand, a few in ground rich in humus, but in such a way that they could not be reached by damp. I must lay especial emphasis on the latter point, since freshly-laid eggs are peculiarly sensitive to wet. More than half the eggs which were

* Oviposition does not appear to take place at the same time in all localities, since Keller mentions the month of January for Nossi-Bé.

placed in pits in my courtyard perished through getting mouldy, in spite of the fact that only a very small degree of moisture could afterwards be detected in the sand. The fresh egg is altogether one of the most sensitive objects with which I am acquainted. A slight increase of temperature also killed the young embryos to a certainty if the eggs were not covered with a sufficient depth of sand. Older eggs, on the contrary, are all the more capable of resistance, and may half dry up, and lie for days uncovered upon the table, without causing the destruction of the embryo.

The Sakalava people told me that when the young are ready to emerge the female scrapes the sand out of the pit; I had no reason to doubt this statement, as I had myself seen numerous pits from which the sand had been removed and which contained the broken egg-shells. This gave rise to the question as to how the mother knows that the eggs are sufficiently developed and that it is time to scrape out the pit. The solution of the riddle was very simple.

In the workroom of my house there stand a few boxes filled with sand containing crocodile eggs, in order that I may have the latter always before my eyes and eventually be able to see the young animals emerge. One day I heard sounds emanating from one of these boxes, and came to the conclusion that a young crocodile had actually hatched and, being buried in the sand, was stifling, and so making these noises. On digging out the sand I discovered the surprising fact that the sounds actually came from the uninjured eggs. The noises are so loud that if the eggs are exposed they may be heard quite distinctly in the adjoining room. If the eggs are covered with sand, as they are in their natural state, therefore to the depth of about 2 feet, the sounds are somewhat deadened, but still distinctly discernible without difficulty at the distance of the length of a room. The cries of the young animals in the egg can be aroused at any time by walking with a heavy tread past the spot where the eggs are lying, or knocking at the box containing the eggs, or taking the egg in the hand and shaking it slightly; every disturbance causes the young animals inside to utter sounds.

Since, as mentioned above, the mother animal sleeps upon the nest, it will in its movements or in its wanderings to and fro between the water and the nest shake the ground, and cause those young animals in the eggs which are sufficiently far developed to emit sounds. The female then scrapes the sand out of the pit, and after some time the young emerge. From eggs of this kind, which were exhumed and kept uncovered, the young emerged in three days.

The fact that sounds are produced by the young in the egg was unknown to anybody here. The natives laughed at me when I spoke about it, until by listening they were convinced of their mistake. The sounds are produced with the mouth closed, apparently by powerful contraction of the ventral muscles, much as we make a noise when hiccoughing. The sound, too, is similar.

When the young animals have emerged the old crocodile goes with them to the water. My taxidermist, a thoroughly trustworthy man, who has previously travelled with Dr. Fischer, told me that a short time before he had seen a large crocodile with a tribe of about twenty young ones travelling over a stretch of sand to the water. He stated that the old one was remarkably savage. That the just-hatched young are able, without help from the mother, to break through the superincumbent layer of sand I believe that I am entitled, according to the experiments which I have made, to deny as emphatically as possible. Of the eggs which were covered with a layer of sand about $1\frac{1}{2}$ to 2 feet in depth it is true that a few showed feeble attempts on the part of the young to escape, in that the shell was broken at one point, while sometimes the young animals had protruded the tip of the snout; but they had invariably perished, probably from want of air. The eggs which were only lightly covered with sand presented no difficulties to the young in escaping.

The process of hatching is preceded by a change in the position of the embryo, with partial destruction of the embryonic membranes, so that the tip of the snout of the young animal now comes into contact with one end of the egg; at any rate this was the position of all embryos which were ready to emerge. The piercing of the egg-shell is effected by the mechanical operation of the egg-tooth, which is also found in young birds. The rudiments of this tooth may be detected at a very early stage, at the period at which the young crocodiles begin to assume their definite shape, therefore when the embryos are about one and a half to two months old. In the just-hatched young it appears as a tooth about $\frac{1}{2}$ to $\frac{3}{4}$ millim. in length, terminating in two points; the movements of the animal cause it to act precisely like a gimlet. In crocodiles a fortnight old it was still distinctly recognizable. On the perforation of the egg the embryonic fluid escapes and produces a softening of the adjacent parts of the shell, and the young animal forces itself backwards through the narrow cleft. A specimen which was watched from the moment it pierced the egg-shell took about two hours to completely emerge. As the animal forces itself through the narrow hole

the embryonic membranes are torn off at the edges of the opening and are left behind in the egg.

The just-hatched young are of considerable size, and it is afterwards difficult to understand how they could have found room in the egg. For instance, an egg 8 centim. in length by 5 centim. in breadth produced a young crocodile of 28 centim. These young animals are very savage from the first; they snap at the finger if one attempts to pick them up, &c. They frequently make a noise, especially when they are hungry. This fact had long been known to me. The note is not so high as that produced by the young in the egg. It sounds pretty much like the cry of our fire-bellied toad (*Bombinator igneus*), but is somewhat louder; it is repeated six or seven times, followed by a pause. Some young crocodiles which I have been observing for about a fortnight in a pool I have not heard to utter any cries during the last day or two. Besides this the animals make a spitting noise if they are irritated, *e. g.* when they are held up by the tail.

Hatching is not directly dependent upon the setting in of the rainy season, and is not occasioned by the increased moisture of the ground, since the greater number of pits contained empty egg-shells about a fortnight before the occurrence of the first fall of rain. Development in the egg takes about three months. It was in the middle of November that I received information that the first newly-hatched young had been observed.

The newly laid egg exhibits the following characteristics.

As has been remarked above, the form and size of the egg are variable, and it possesses a hard and coarsely granulated shell. Immediately beneath this lies the thick and tough shell-membrane, which is so resistant that the egg retains its form after the removal of the shell. This shell-membrane consists of two layers, a thicker external and a more delicate internal one. It is possible with a little care to peel off the external layer in large pieces. S. F. Clarke * states that the shell-membrane of the alligator is attached to the shell in a ring-shaped zone in the direction of the smaller diameter, and that even from outside the egg appears to be encircled by a readily distinguishable white zone. Nothing of this is to be seen in the perfectly fresh eggs of the crocodile. Crocodile eggs which presented this appearance underwent no further development.

The albumen is of about the same consistency as jelly, sometimes has a greenish lustre, and is so tough that, after care-

* S. F. Clarke, "The Nest and Eggs of the Alligator, *Alligator lucius*, Cuv.," Zool. Anzeiger, 1888, no. 290, p. 568.

fully removing the shell-membrane, the entire egg may be taken in the hand, rolled about, examined from every side, and even allowed to slide from one hand into the other without collapsing. The yolk is globular and so large that it reaches almost to the long sides of the shell-membrane. The colour is somewhat brighter than in the case of the fowl. The vitelline membrane is very delicate, but so tough that it is possible with a little practice to remove the albumen entirely, until finally only the yolk is retained in the hand; the yolk then naturally assumes the shape of a round flat cake.

I must agree with S. F. Clarke in stating that the egg of the crocodile is the tenderest and most difficult object to manipulate imaginable, since the conditions which have just been described apply to perfectly fresh eggs only; subsequently it is only extremely seldom that the egg can be prepared without injury. I adopted the expedient of first removing one half of the egg-shell and then half of the shell-membrane, which I succeeded in doing without damaging the albumen; then, turning the egg gently, I searched for the embryo; if I discovered it I opened the albumen and yolk by a quick cut with the scissors, and then allowed the embryo to slide slowly into a watch-glass; the whole was then lifted up, and further manipulated under a dissecting-microscope. In spite of every precaution all my trouble was often thrown away.

It is stated by S. F. Clarke that it is possible to determine the position of the embryo from without by the fact that at one spot the above-mentioned ring-shaped white zone is expanded. This statement is not applicable to *Crocodilus niloticus*, since an expansion of the zone is found even in bad eggs, in which the embryo has perished. Eggs which develop normally exhibit no trace of change in their external appearance until the escape of the young animal, but appear pure white.

It would be premature at the present moment to attempt to give a review of the entire course of the embryonic development, since my investigations are not yet concluded and will need a supplementary examination next year, for unfortunately perfectly new-laid eggs have not come to hand so plentifully as might have been wished.

The youngest embryos observed, about six days old, were dumbbell-shaped and 3 millim. in length; the amnion was not yet closed. The object is unfortunately so delicate that I have not yet succeeded in examining these stages under the microscope, and I was obliged to confine myself to preserving these as well as the perhaps even younger stages *in toto*.

So far as I have yet been able to determine, the development of the crocodile closely resembles that of the bird. A noticeable feature is the tail, which is of great length at a very early stage, and is at first rolled up in a spiral form, and afterwards, when the embryo is more strongly bent, twisted round the neck.

That the rudiment of the egg-tooth appears very early has already been mentioned.

Rudiments of the genital protuberance are already to be seen in embryos which are about 10 millim. long (measured in the bent position). A rod-shaped structure may then be observed between the posterior legs; it is about 1 millim. in length and protrudes from the cloaca, with the anterior wall of which it is fused. It at first lies parallel to the median line of the abdomen, is subsequently erected, and finally completely retracted within the opening of the cloaca. It is not until the embryos are almost full-grown, after about two and a half months, that the genital protuberance begins to disappear altogether, and is then only to be seen by separating the lips of the cloaca.

IX.—*On newly-discovered East-African Chameleons, with Remarks on some other Reptiles described by Dr. Steindachner.* By G. A. BOULENGER.

JUDGING from the number of descriptions recently published* it would seem that the Chameleon fauna of East Africa is likely soon to rank next to that of Madagascar with regard to variety of species. I have, however, no doubt that the list of species has to be reduced by three, of which two have just been described by Dr. Steindachner and the third by Mr. Stejneger. On comparing the descriptions and figures of *Chameleon Höhnelii* and *leikipiensis* with the late J. G. Fischer's account of *Ch. biteniatus* and the specimens in the British Museum, I cannot come to any other conclusion but that they all belong to one and the same species, Dr. Steindachner's specimens being fully-developed males. The

* *Chamaleon sphaerophilis* (Victoria Nyanza) and *Fischeri* (Usagara?), Reichenow, Zool. Anz. 1887, pp. 370 and 371; *Ch. Roperi* (Kilifi), Boulenger, P. Z. S. 1890, p. 85, pl. viii. fig. 4; *Ch. Höhnelii* (Leikipia, west of Kenia, 6000 feet), *leikipiensis* (Leikipia), and *tavetensis* (Taveta, foot of Kilimandjaro), Steindachner, Anz. Ak. Wien, 1891, pp. 141 and 142, and Sitzb. C. 1891, pp. 307, 309, 310, pl. i.; *Ch. Abbotti* (Kilimandjaro), Stejneger, Bull. U. S. Nat. Mus. xiv. 1891, p. 353; *Rhampholeon Robecchii* (Somaliland), Boulenger, Ann. Mus. Genova (2) xii. 1891, p. 11, pl. i. fig. 3.